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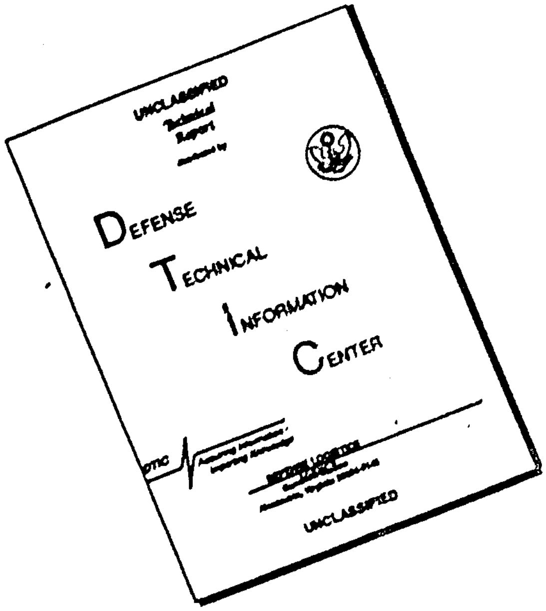

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NWL Report No. 1741

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INVESTIGATION OF 3"/70 CARTRIDGES
FROM AMMUNITION LOT PV-4-C-57

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DAHLGREN, VIRGINIA

629925

Date: 23 February 1961

U. S. Naval Weapons Laboratory
Dahlgren, Virginia

Investigation of 3"/70 Cartridges

from Ammunition Lot PV-4-C-57

by

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Task Assignment
NO 180-835/56002/04-064

23 February 1961

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CONTENTS (Continued)

ABSTRACT

The premature ignition of a 3"/70 cartridge aboard the USS WILLIS A. LEE (DL-4) resulted in a serious casualty. Various tests with cartridges and cartridge components from the same ammunition lot, PV-4-C-57, failed to reproduce a similar preignition. It was concluded that: the cartridges from ammunition lot PV-4-C-57 appear to be serviceable; the premature ignition, upon ramming, of a 3"/70 cartridge probably would not be caused by solid propellant grain slivers or black powder grains becoming lodged between the cartridge case and projectile; the wad for a full case assembly is not adequate for all 3"/70 full service charge assemblies; the proposed bullet pull-out load requirements are unrealistic for the Mk 34 Mod 3 projectile; and that electromagnetic radiation was not the cause of the casualty. It was recommended that two Pc. No. 26 (wads) be used in a full case assembly, a wad of 4-inch diameter be adopted and used together with two distance pieces whenever Pc. No. 26 is inadequate; i. e., for a PPD range from 2".2 to 4".5 inclusive, and the proposed bullet pull-out load requirements be changed since the Mk 34 Mod 3 projectile would not be able to meet these requirements as they now stand; i. e., a bullet pull-out load for a test round should be between 14,000 and 21,000 pounds and the average of any three consecutive test rounds should be a minimum of 15,000 pounds.

FOREWORD

This is a report of an investigation of 3"/70 cartridges from ammunition lot PV-4-C-57. A cartridge from this lot was involved in a casualty aboard the USS WILLIS A. LEE (DL-4). Interested personnel of the Bureau of Naval Weapons were informally informed of most of the contents of this report as soon as the results were known. Based on results of tests here and at other Naval establishments, reference (a) lifted the suspension of approximately sixteen lots of 3"/70 ammunition. Work was conducted under Task Assignment NO 180-835/56002/04-064.

This report was reviewed by the following members of the Weapons Development and Evaluation Laboratory:

M. L. HUNT, Head, Initial Ballistics Branch
D. C. SLOAN, Acting, Head of Armament Division
D. W. STONER, Acting Director

APPROVED FOR RELEASE:

/s/ R. H. LYDDANE
Technical Director

INTRODUCTION

A 3"/70 cartridge from ammunition lot No. PV-4-C-57 was involved in a casualty aboard the USS WILLIS A. LEE (DL-4). This casualty resulted from premature ignition of the propellant. From the examination of the damaged mount and cartridge case fragments, it was believed that the explosion occurred when the rammer case was near the end of the ram cycle at the position where the round was in line with the bore of the gun, and the after end of the cartridge case was in the rammer case. Reference (b) requested the Naval Weapons Laboratory, Dahlgren to conduct the tests proposed in reference (c) and to conduct additional tests using standard 3"/70 cartridge assemblies to determine the force required to separate the projectile from the cartridge case.

DESCRIPTION OF ITEM UNDER TEST

The 3"/70 cartridges from ammunition lot PV-4-C-57 were assembled with the following components:

a. Projectile: HE-VT, Mk 34 Mod 2 assembled with VT Fuze Mk 75 Mod 2 (SD)

b. Propellant: SPCG-10695 (IHPC-15CG) at 10.09 lbs.

c. Primer: Mk 49 Mod 1

d. Cartridge Case: Mk 10 Mod 0

DESCRIPTION OF TEST EQUIPMENT

Radiography

Radiographic inspection was conducted with either the 250-KVP industrial X-ray generator or a 20-curie source of cobalt 60.

Mount

The 3-inch gun mount Mk 37 is a twin, enclosed, dual purpose mount with an automatic ammunition handling system capable of firing at a rate of 90 rounds per minute. O. P. 1718 (Volume 1) gives a detailed description of this mount.

Gun Barrel

The 3"/70 caliber antiaircraft gun barrel, Mk 26 Mod 0, is characterized by interface cooling and disappearing rifling of uniform 1/20 twist. It has high contraction chrome plating of uniform thickness (0".006) throughout the bore and chamber. Details of the design may be found on Bureau of Ordnance Drawing Nos. 516705, 516710, 660834 and 660836.

Instrumentation

Endevco high frequency accelerometers and Microdot low noise cables were used to measure vertical and axial or lateral and axial accelerations of dummy cartridges during transport from hoist to rammer case and from rammer case to gun barrel chamber. A 4-beam cathode-ray oscillograph was used to record the measurements.

PROCEDURE AND RESULTS

Radiography

Thirty complete rounds were radiographically inspected primarily to ascertain the position of the wad in the assembly. The radiographs were obtained by using a 20-curie source of cobalt 60 and with a 6-foot source-to-film distance. Most of the wads were observed to be lying on top of the propellant bed. Figures 1 and 2, Appendix A, are radiographs that show the two extreme positions. The former shows the wad next to the base of the projectile and the latter shows the wad beneath the surface of the propellant bed. Radiographs referred to hereafter were obtained by using a 250-KVP industrial X-ray generator with a 4-foot source-to-film distance.

Visual Inspection

Twenty of the cartridges radiographed were disassembled and the components visually inspected. The propellant appeared to be normal. No slivers, exudates, or cracked, crushed or deteriorated grains were found. Samples of the propellant were sent to the Naval Propellant Plant, which in reference (d) reported that no significant changes in composition, stability or impact sensitivity were noted. It was observed that about half of the primers had cocked end seals.

Drop Test

Ten primers were subjected to a 40-foot drop test as specified in reference (e) with two primers at each of the required orientations. All of the primers withstood the test without firing although the tube of one primer broke off at the stock. This primer was dropped in the stock-up, primer-tube-vertical orientation. Figure 3, Appendix A, is a photograph showing the post-test condition of the primer together with an undamaged primer. No defects were noted upon examining the radiographs of this primer. Two views, 90 degrees apart, are shown in Figure 4, Appendix A.

Ramming Tests

To investigate the possibility of propellant slivers or black powder becoming wedged between the cartridge case and projectile and subsequently igniting during the ramming process, several ramming tests were conducted. One possibility considered was that a primer might lose its end seal, allowing some of the black powder charge to work forward and eventually become lodged between the cartridge case and projectile. Four cartridges assembled with inert propellant and projectiles, and primers from ammunition lot No. PV-4-C-57 were cycled through the automatic ammunition handling system of the Mk 37 Mount. Subsequent examination showed no change in the end seals. Five cartridges similarly assembled but with the primer end seals removed were also cycled. Subsequent examination showed that the black powder charges remained in the primer tube. In spite of these negative results, for the sake of completeness it was assumed that black powder somehow did get to the forward section of the cartridge case. A special cartridge was assembled which consisted of inert propellant and projectile, with black powder grains and dust distributed as shown in Figure 5, Appendix A. Seven cycles through the Mk 37 Mount failed to ignite the black powder. Two other special cartridges were assembled. Smokeless powder grains were sectioned longitudinally and placed between the cartridge case and projectile. All the other components were inert. The first special round was cycled once through the Mk 37 Mount without ignition occurring and the second special round was cycled ten times without ignition occurring. Figure 6, Appendix A, is a radiograph of the former showing some sectioned grains remaining after cycling and Figures 7 and 8, Appendix A, are radiographs, two views 30 degrees apart, of the latter showing some sectioned grains remaining after cycling. The inert primer used in the second special round was a Mk 45 so that a PPD (Production Packing Depth) could be obtained that was closer to that of the service round.

Bullet Pull-Out Tests

The Bureau of Naval Weapons has the intention of revising the loading assembly drawing to specify the following bullet pull-out range and test method:

"Note: Round shall be crimped to produce a bullet pull-out load between 14,000 and 21,000 pounds. The average of any three consecutive test rounds shall have an average bullet pull-out load of 15,000 pounds minimum. Test shall be performed by pulling cartridge at a uniform rate of 1.0 inches/minute."

To confirm the adequacy of these requirements, five cartridges assembled with the Mk 34 Mod 2 projectile and five with the Mk 34 Mod 3 projectile and crimped with a pressure of 135 long tsi were tested. Tests were performed by pulling cartridges at a uniform rate of 1.0 inch/minute. The results are tabulated below.

TABLE 1

PULL-OUT LOAD (lbs)	
Mk 34-2 Projectile	Mk 34-3 Projectile
15,950	13,200
17,500	14,600
16,820	14,740
15,080	15,320
17,140	15,100

It appears that the requirements are not being met by the Mk 34 Mod 3 projectile.

Acceleration Measurements

Accelerations experienced by 3"/70 cartridges in the Mk 37 mount from the last dwell position on the hoist to the seating position in the gun chamber were measured at the request of the Naval Weapons Plant. The accelerometers were arranged to obtain the accelerations in the vertical and axial or lateral and axial directions of motion. The testing, of necessity, was divided into two parts. The first phase consisted of measuring the accelerations during movement of the round from the last dwell position on the hoist to the rammer case position and the second phase from the rammer case position to the gun chamber. Two types of round designs were utilized to better accomplish each phase of the testing. Both rounds were constructed so that the accelerometers would be

mounted on a machined lock screwed into the primer hole in the base of the case. The accelerometers were secured with an adhesive to the blocks to isolate them electrically. Inert propellant was used to bring the round to weight. Endevco high frequency accelerometers and Microdot low noise cables were used in each round. Round No. 1, Figure 9, of Appendix A was designed for the hoist-to-rammer case phase of the cycle, the leads to the accelerometers being brought out through a hole drilled in the projectile. In this manner the leads were protected when the round was thrown into the rammer case. Round No. 2, Figure 9, of Appendix A was designed for the rammer case-to-gun chamber phase, the accelerometer leads being brought out through holes in the base of the cartridge case. Slots were milled in the base of the case to protect the leads against damage upon closing of the breechblock after the round was rammed. A timing device was used in both phases in order to compare the actual mount operating speed with that given in the operational literature. For the first phase, first motion was indicated by a break-wire device and the end of motion time signal from the rammer-loaded switch, J301. For the second phase, first motion was obtained by using a microswitch attached to the rammer case and end of motion time signal from the breech-closed switch, J341. For the first phase tests, the round was hand loaded onto the hoist at the vertical lift section. Careful attention was given to insure that the round was properly placed to provide the required accelerometer orientations. The round was then hand cranked into the normal dwell position. With the mount in power operation, the firing trigger was depressed, sending the round into the rammer case as shown on Figure 10, Appendix A. In the second phase tests, the round was hand loaded into the rammer case. The accelerometer leads were taped to the projectile to prevent destruction by the round positioners. With the mount in power operation, the round was thrown into the gun chamber as shown in Figure 11, Appendix A. The results of the acceleration measurement tests are shown in Tables 2 and 3, Appendix B. The various operations of the loading cycle were identified on the records by the motion indicating signals and the normal cycle operations given in the operating literature. Figure 12, Appendix A, is a representative test record for phase one, on which the various cycle positions are noted. The recording trace was overlapped to obtain a longer time interval and make possible the identification of the various portions of the record. In phase two, the cabling to the accelerometers was severed by the extractor lip upon striking the breechface, making it necessary to replace cables on each test. The data obtained indicate the maximum values of acceleration that could be observed on the records. The records consisted of high frequency transients. The frequencies obtained were higher than those that can be accurately reproduced by the accelerometers. The accelerometers are able to respond to 70,000 cps but are calibrated within five per cent to only 14,000 cps. It is felt that the accelerometer error will not exceed thirty per cent of the reported values. The cycle times recorded were in close agreement with operational literature.

DISCUSSION

Cartridge Assembly

The chief concern expressed about the 3"/70 cartridge assembly was the method of containing the propellant in the "as loaded" condition until the cartridge is expended. The concern was twofold. First, should the propellant not be contained, there is a possibility that solid propellant slivers may become lodged between the cartridge case and projectile which could result in pinching of the slivers and possible premature ignition. This possibility is not entirely discounted, although test results were negative. Second, a change in the assigned and loaded PPD leads to an increase in ballistic dispersion. At present, reference (f) is the only known full charge service assembly drawing. Only a full case assembly is shown; i. e., no provision is made for spacers (distance pieces). Piece No. 26 of reference (g) is the only wad specified and this wad, having a nominal diameter of 3-3/8", is designed for full case assembly. The 3"/70 picrite propellant provides a bulky grain developed to give a full case when assembled at the service charge. Because of variations in charge assignment, a completely full case does not always result. Specifically, out of 27 indexes recommended for acceptance by the Naval Weapons Laboratory, Dahlgren, five indexes had PPDs recommended that were other than the full case PPD of 1".7. The indexes were the following:

TABLE 4

INDEXES WITH PPD OTHER THAN FULL CASE

Designation	Index	Recommended PPD
IHPC-9CG	SPCG-10657	3".2
IHPC-11CG	SPCG-10687	3".8
IHPC-14CG	SPCG-10680	3".6
IHPC-15CG	SPCG-10695	3".4 (Reference (h))
IHPC-18CG	SPCG-10698	3".2

The Naval Weapons Laboratory, Dahlgren has no record of the Bureau of Naval Weapons' assignment of charge weight, PPD, etc. for the 3"/70 propellants. It is assumed that a full case assembly was requested for the propellant index, SPCG-10695, of ammunition lot PV-4-C-57. This could have been accomplished in one of two ways. The propellant could have been poured PPD with the wad, Pc. No. 26, placed in the top of the case, or poured loose to obtain a full case (PPD = 1".7) with the wad placed on top of the propellant. If the propellant were loaded loose,

the bed would soon settle to the actual PPD with normal handling of the cartridges. At a PPD of 3".4, the nominal inner diameter of the cartridge case is approximately 0".338 greater than the diameter of Pc. No. 26. For several years the Naval Weapons Laboratory, Dahlgren has been using two wads in the 3"/70 cartridge assembly, Pc. No. 26 and a wad about 4".0 in diameter. From what could be determined, the latter's use was begun upon the oral recommendation of the Bureau of Naval Weapons and is used together with spacers of appropriate length for assemblies in which Pc. No. 26 is inadequate. The two aforementioned wads are adequate for PPDs to a maximum of about 4".5. To facilitate insertion of the wad into the cartridge case, the wad is split once through half a diameter to enable overlapping. If the diameter of the wad used is less than the inner diameter of the cartridge case, a spreading of the overlap (as can be seen in Figure 1 of Appendix A) would allow whole grains and slivers, if any, to get between the wad and projectile. To obviate this and to adequately contain the charge, two wads and, if required, spacers cut to required length should be used. The second wad should be placed on top of the first in a manner such that the split of one is diametrically opposite to that of the other.

HERO (Hazards of Electromagnetic Radiation to Ordnance)

An on-site investigation of the casualty revealed that the round from ammunition lot PV-4-C-57 initiated during the end of the ramming cycle after the projectile was part way into the gun chamber, but before the breechblock was unlatched by the round striking the extractor. It was not determined whether or not the Gunar transmitter was in operation. From a study of the operating manual it appears that the premature ignition of the round occurred between the time the round was thrown from the rammer case and the time the rim of the cartridge case would have struck the extractor toes. During this interval there is no possibility that the firing pin could have come in contact with the primer and furthermore, it is improbable that any metal portion of the rammer case could have come in contact with the primer. Since these two possibilities will have to be ruled out there would not have been a completed electrical circuit through the primer bridge wire even if there were strong RF fields inside the mount.

When the round is propelled into the rammer case, it is centered by three metal round-centering and supporting chocks. A metal round-securing latch, actuated by spring tension, secures the round by the rim of the cartridge case in the rammer case when the round is seated. The round is buffed in the rammer case by a metal hydraulically operated case seat buffer. Since the metal round-centering and supporting chocks make contact with the cartridge case and the round-securing latch

contacts the rim of the cartridge case, it is felt that an RF potential could not have existed across the primer bridge wire while the round was in the rammer case.

Two tests have been conducted with gun ammunition to determine the vulnerability of the ammunition components to RF radiation. One test was conducted on the USS H. J. THOMAS (DDR-833) with 5"/38 caliber gun ammunition components in a 5"/38 mount and the other was conducted at this Laboratory using 5"/54 caliber ammunition components in a 5"/54 mount. The former was of a go/no-go nature and the results were negative whereas the latter was instrumented and go/no-go. The go/no-go test demonstrated that the ammunition would not initiate when normally handled aboard ship. The instrumented test revealed that RF energy could be measured at the bridge wire only when someone touched the primer contact, completing the circuit through the person to ground or when the round was inside the gun chamber and the firing circuit was connected. These tests were conducted using an AN/FRT-5 transmitter radiating at 4 to 26 mc at 4 kw average power output. The ignition element had the same electrical characteristics as the 3"/70 Mk 49 primer. These tests, therefore, demonstrated that a circuit must be completed through the bridge wire before RF energy could be detected.

CONCLUSIONS

From the results of the tests and studies conducted, it is concluded that:

a. The cartridges from ammunition lot PV-4-C-57 appear to be serviceable.

b. The premature ignition, upon ramming, of a 3"/70 cartridge probably would not be caused by solid propellant grain slivers or black powder grains becoming lodged between the cartridge case and projectile.

c. The wad for a full case assembly is not adequate for all 3"/70 full service charge assemblies.

d. The proposed bullet pull-out load requirements are unrealistically high for the Mk 34 Mod 3 projectile. The stated requirements are that the bullet pull out load should be between 14,000 and 21,000 pounds and that the average load of any three consecutive test rounds should be a minimum of 15,000 pounds.

e. Electromagnetic radiation was not the cause of the casualty.

RECOMMENDATIONS

It is recommended that:

a. The cartridge assembly be changed as follows:

(1) Use two Pc. No. 26 for a full case assembly. One wad should be placed on top of the other in a manner such that the splits of the two wads are diametrically opposite. Pc. No. 26 is adequate to a PPD of about 2".1 which includes the depot loading tolerance. The "full charge assembly" drawing, reference (f), should be revised as required.

(2) Adopt a wad with a diameter of 4".0. Two wads placed in the same manner as Pc. No. 26 should be used. This wad is to be used within the PPD range of 2".2 to 4".5 inclusive of depot loading tolerances. Within this PPD range, two distance pieces, one within the other, cut to the required length should be used. The "full charge assembly" drawing, reference (f), and the "distance pieces and wads for cartridge cases" drawing, reference (g), should be revised as required.

b. The proposed bullet pull-out load requirements be changed since the Mk 34 Mod 3 projectile would not be able to meet these requirements as they now stand. The proposed requirements are stated in the section on PROCEDURES AND RESULTS under Bullet Pull-Out Tests. A satisfactory solution would be to change the bullet pull-out load values from 14,000, 21,000 and 15,000 pounds to 11,000, 18,000 and 12,000 pounds, respectively. As an alternative, these changes could be made to apply only to the Mk 34 Mod 3 projectile and the proposed requirements could be made to apply to the Mk 34 Mod 2 projectile (the Mk 34 Mod 1 projectile is no longer manufactured).

REFERENCES

(a) BUWEPS ltr FQQA-323:WLS of 10 May 1960 to NAD, Crane

(b) BUWEPS ltr RMMP-341-LM:bas of 30 Dec 1959

(c) COMNAVWPNLAB, Dahlgren ltr WWI:MLH:dmr 8030 of 17 Nov 1959

(d) NPP Conf ltr 8032 (RS-4867)P5a2(60-60) DGP:mvm Ser 0162 of 29 Mar 1960 to BUWEPS

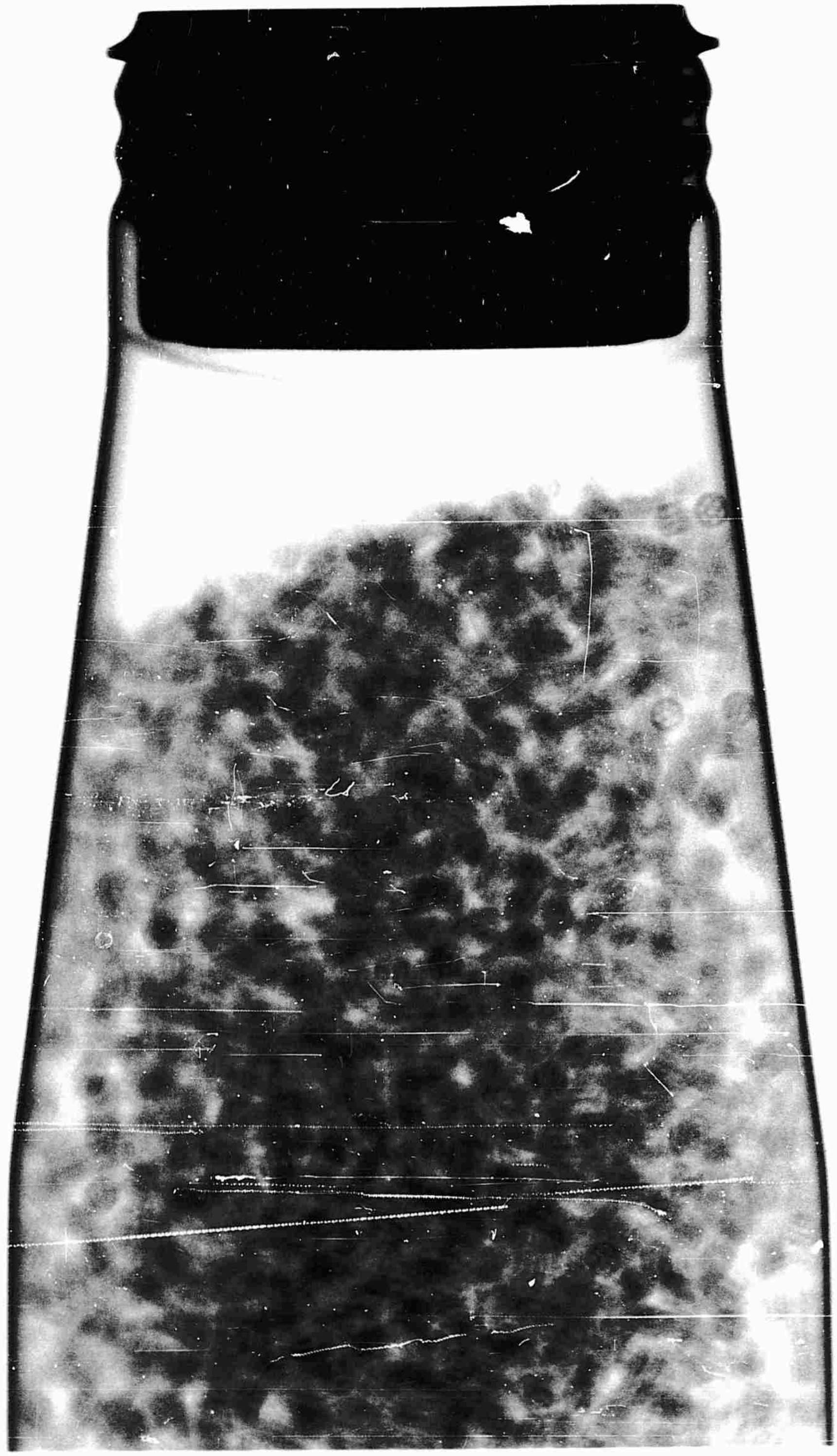
(e) BUORD Dwg. No. 1402964, Requirements and Test Procedures for Primer Mk 49 Mod 0 and Mod 1

(f) BUORD CONF Dwg. No. 380897, Full Charge Assembly for 3"/70 Complete Round with Mk 34 Projectile

(g) Dwg. No. 132664, Distance Pieces and Wads for Cartridge Cases

(h) CONF Powder Test Report X21/9-15/370 of 16 Apr 1957, Powder Test Sheet No. 15233 for IHPC-15CG (SPCG-10695)

APPENDIX A



PHD-56023-11-60 Figure 1

Wad component of the assembly next to the base of the projectile.

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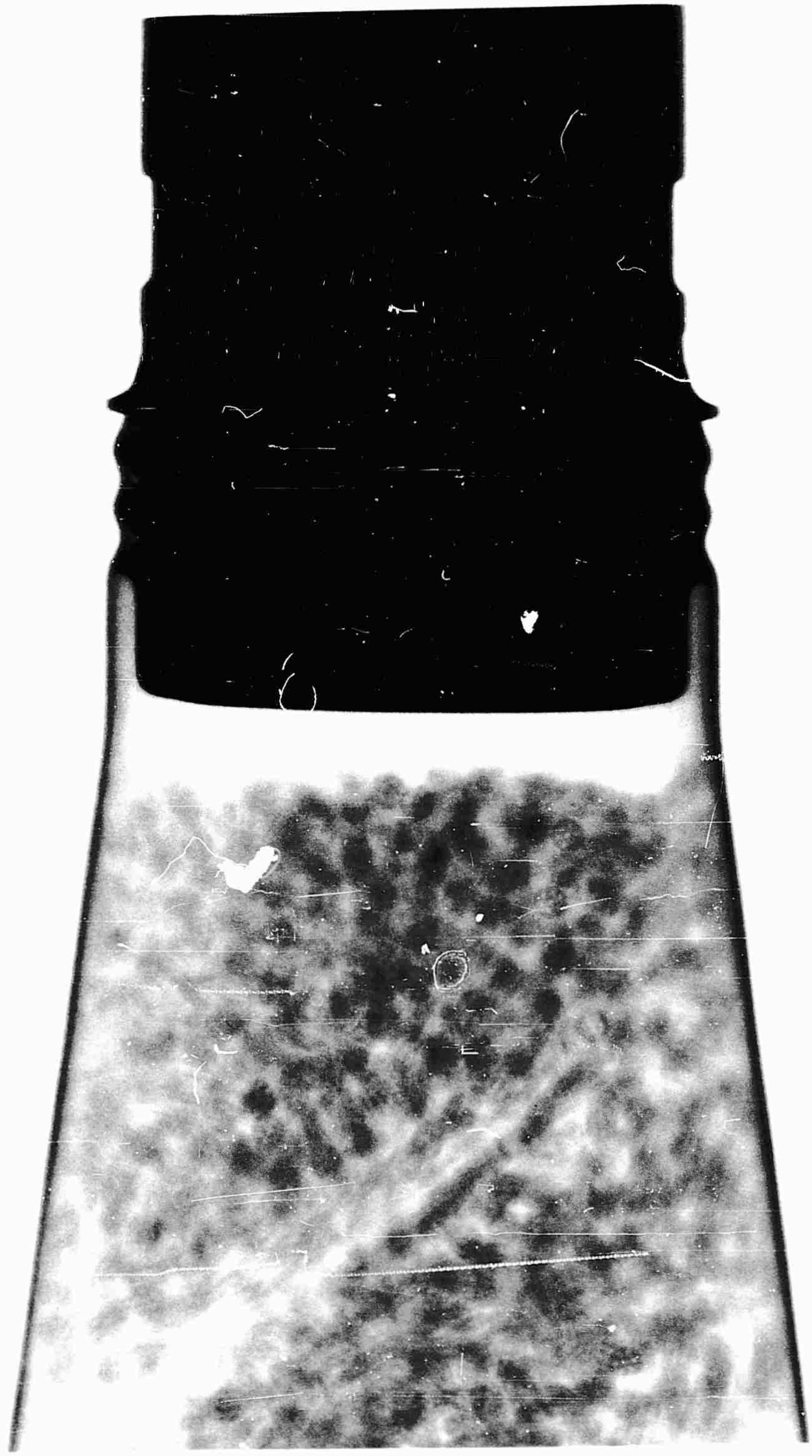

PHD-55646-4-60 Figure 2

Wad component of the assembly beneath the surface of the propellant bed.

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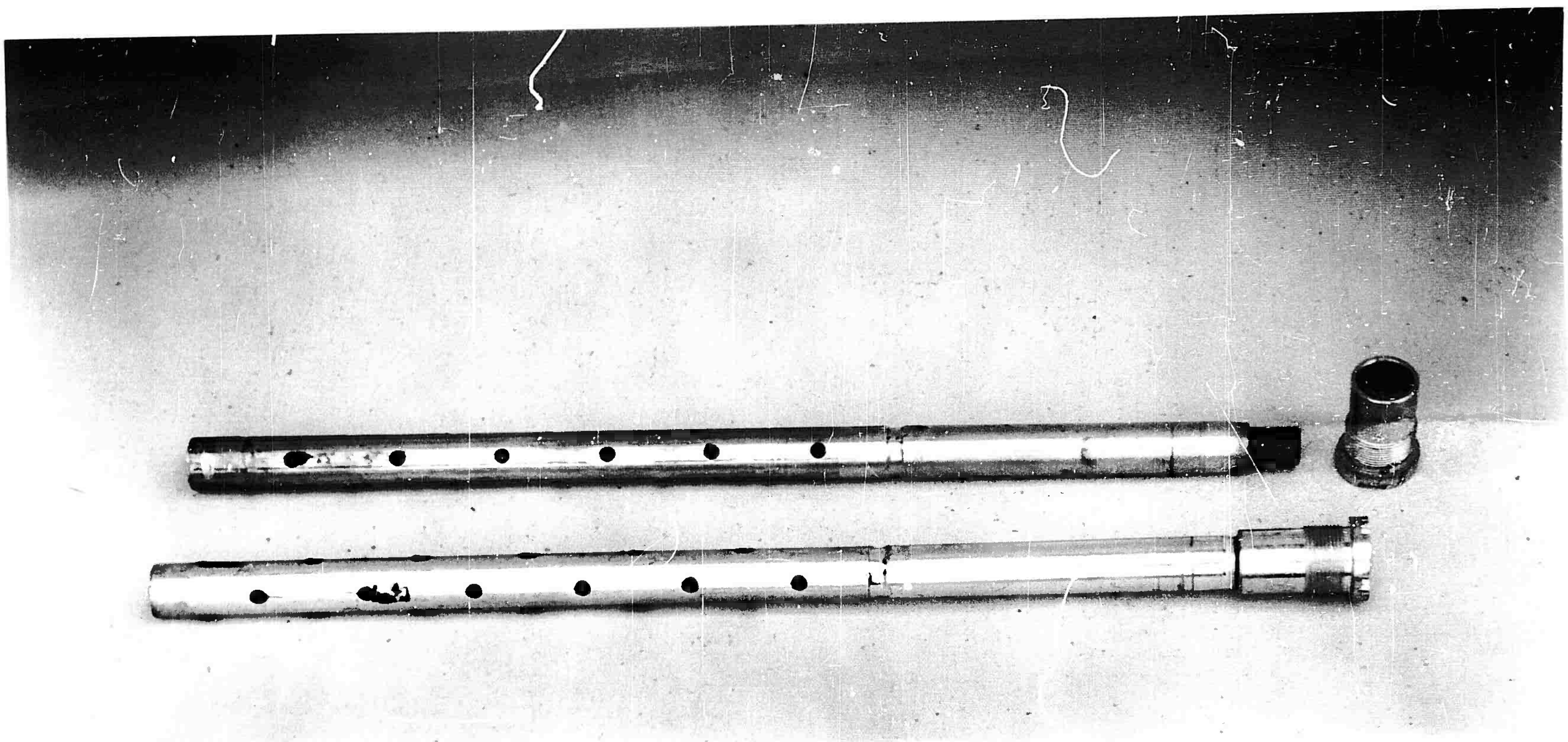

NOD-54327-P-60 Figure 3 10 February 1960

Top: Primer tube failure after being dropped 40 feet in the stock up primer tube vertical orientation.
Bottom: Standard primer assembly.

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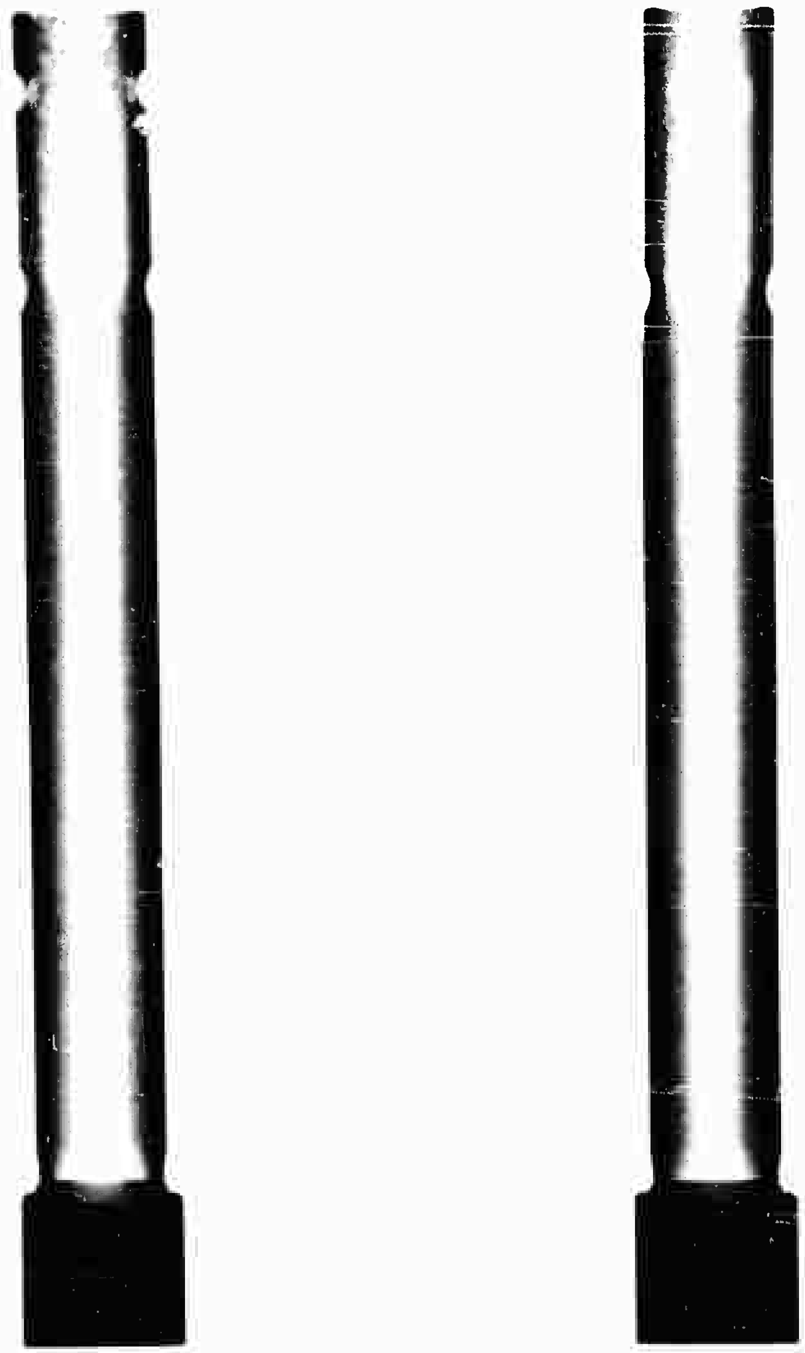

PHD-55645-4-60 Figure 4

Two views, 90 degrees apart, of a primer whose tube failed as a result of a 40-foot drop test. Primer was in the stock-up, primer-tube-vertical orientation.

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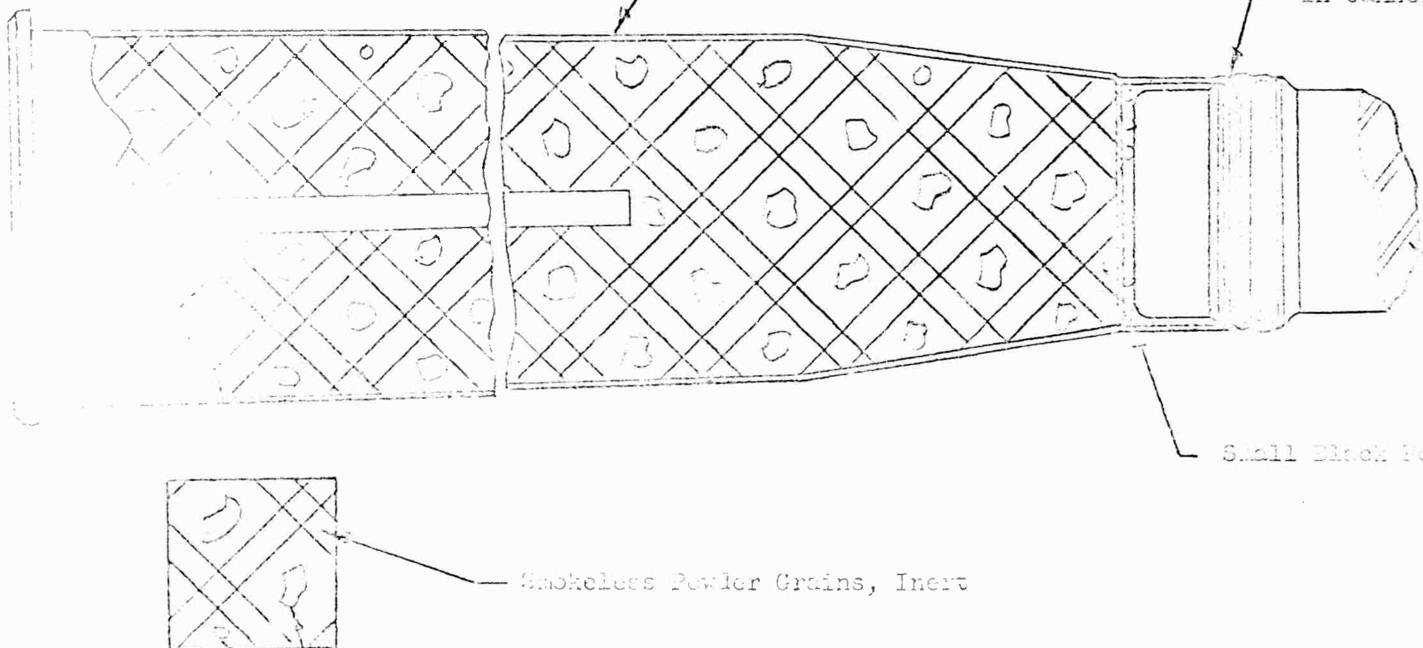
3"/70 CARTRIDGE
SPECIAL ASSEMBLY



NOTES:
1. Prior to assembly perforate case with 1 - [illegible] holes throughout length of case - distance between centers to be [illegible]" both circumferentially and longitudinally.
2. Seal holes with cellophane tape.

Figure 5

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PHD-55648-4-60

Figure 6

First special round showing sectioned solid propellant grains remaining after one cycle through the Mk 37 Mount.

PHD-55647-4-60 Figure 7

Second special round showing sectioned solid propellant grains remaining after ten cycles through the Mk 37 Mount.

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PHD-55649-4-60 Figure 8

Second special round showing sectioned solid propellant grains remaining after ten cycles through the Mk 37 Mount. Rotated 30 degrees from Figure 7.

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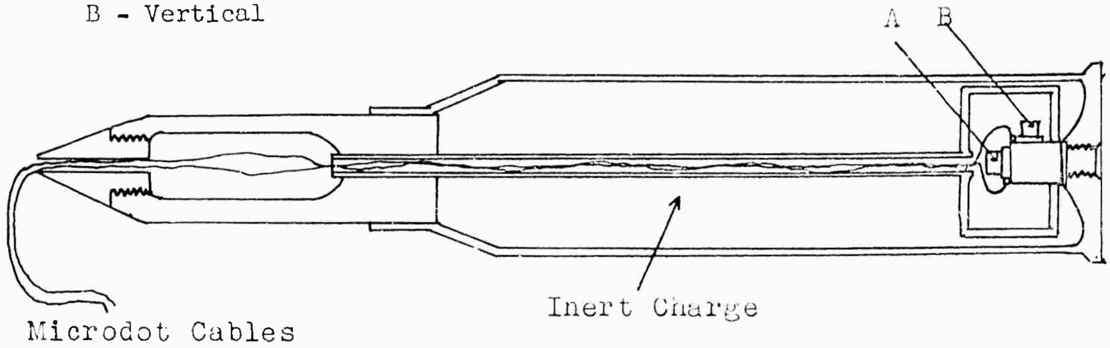
ROUND NO. 1
Sectional View
(not to scale)

A - Axial

B - Vertical



ROUND NO. 2
Sectional View
(not to scale)

A - Axial

B - Lateral

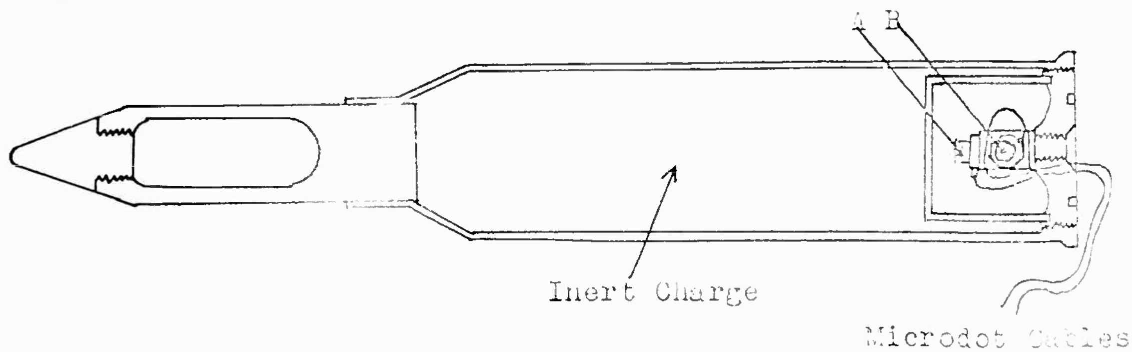
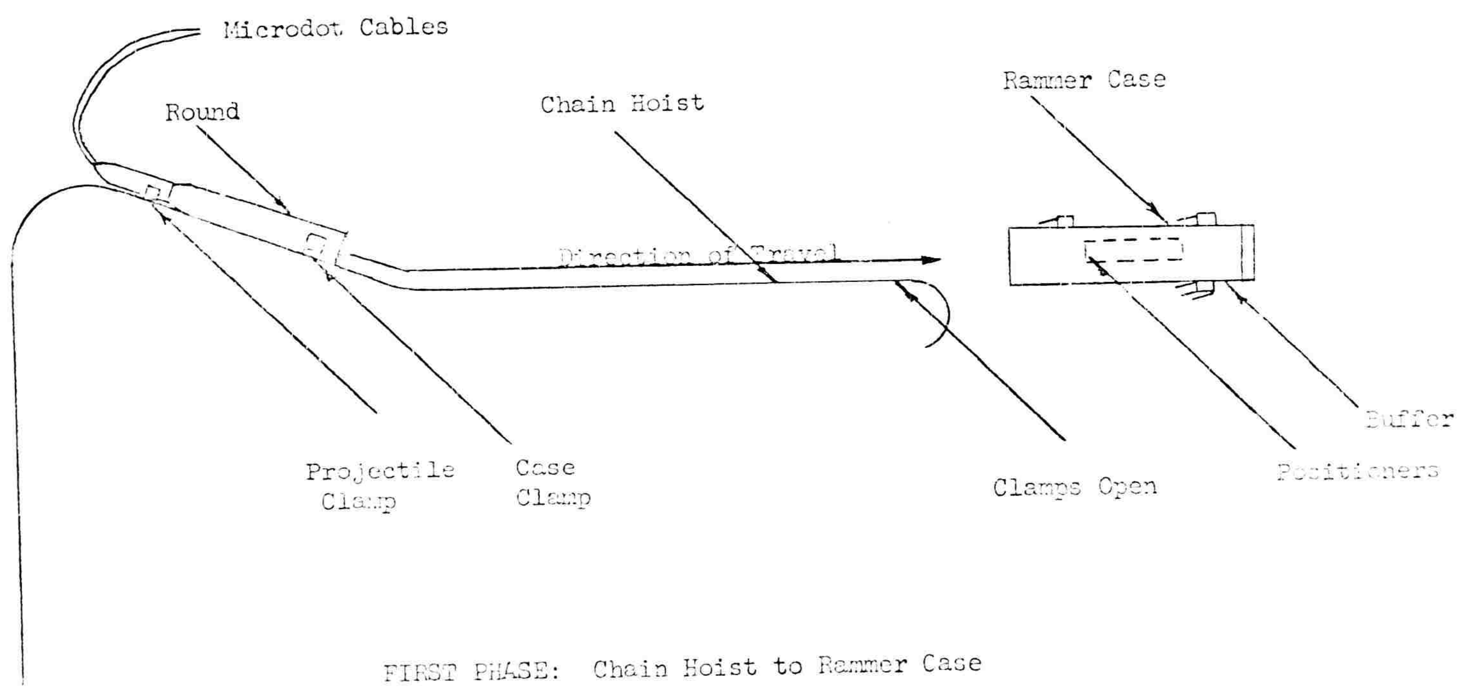


Figure 9

Side View of Mount
(Not to Scale)



FIRST PHASE: Chain Hoist to Rammer Case

Figure 10

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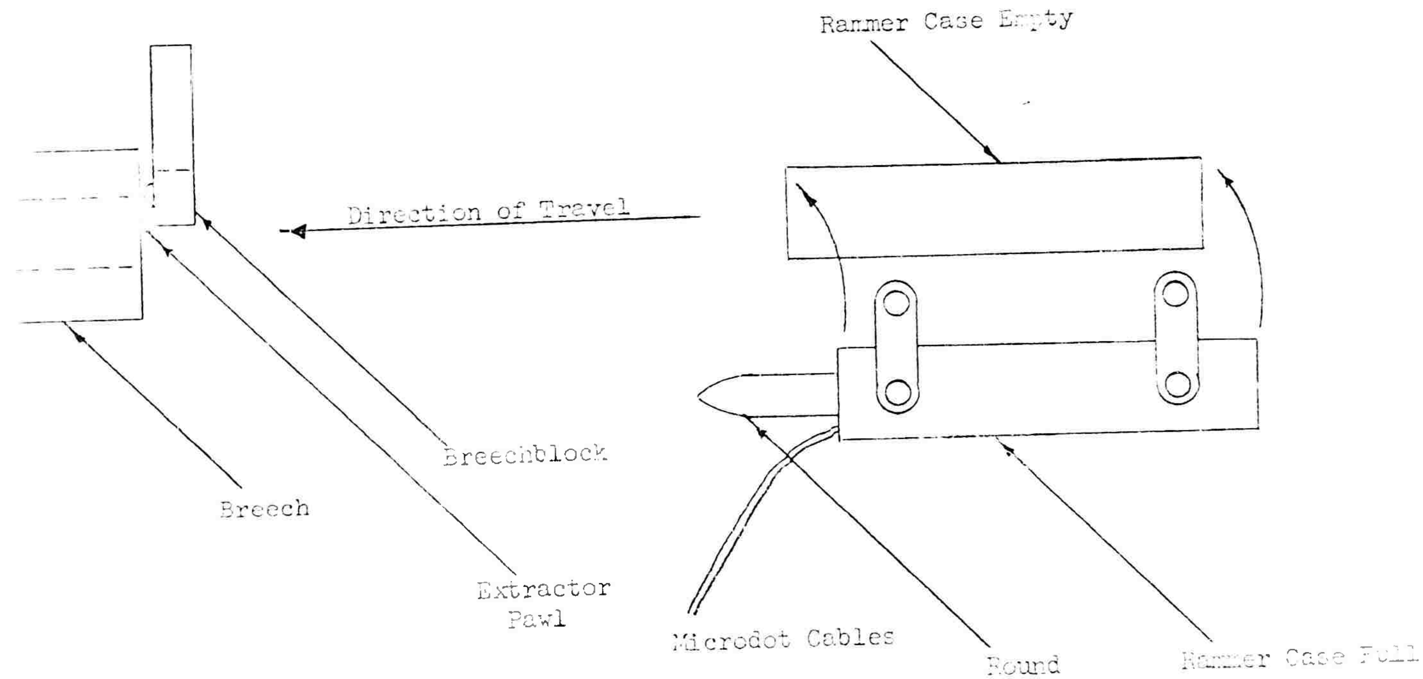
Top View of Mount
(Not to Scale)



SECOND PHASE: Rammer Case to Gun Chamber

Figure 11

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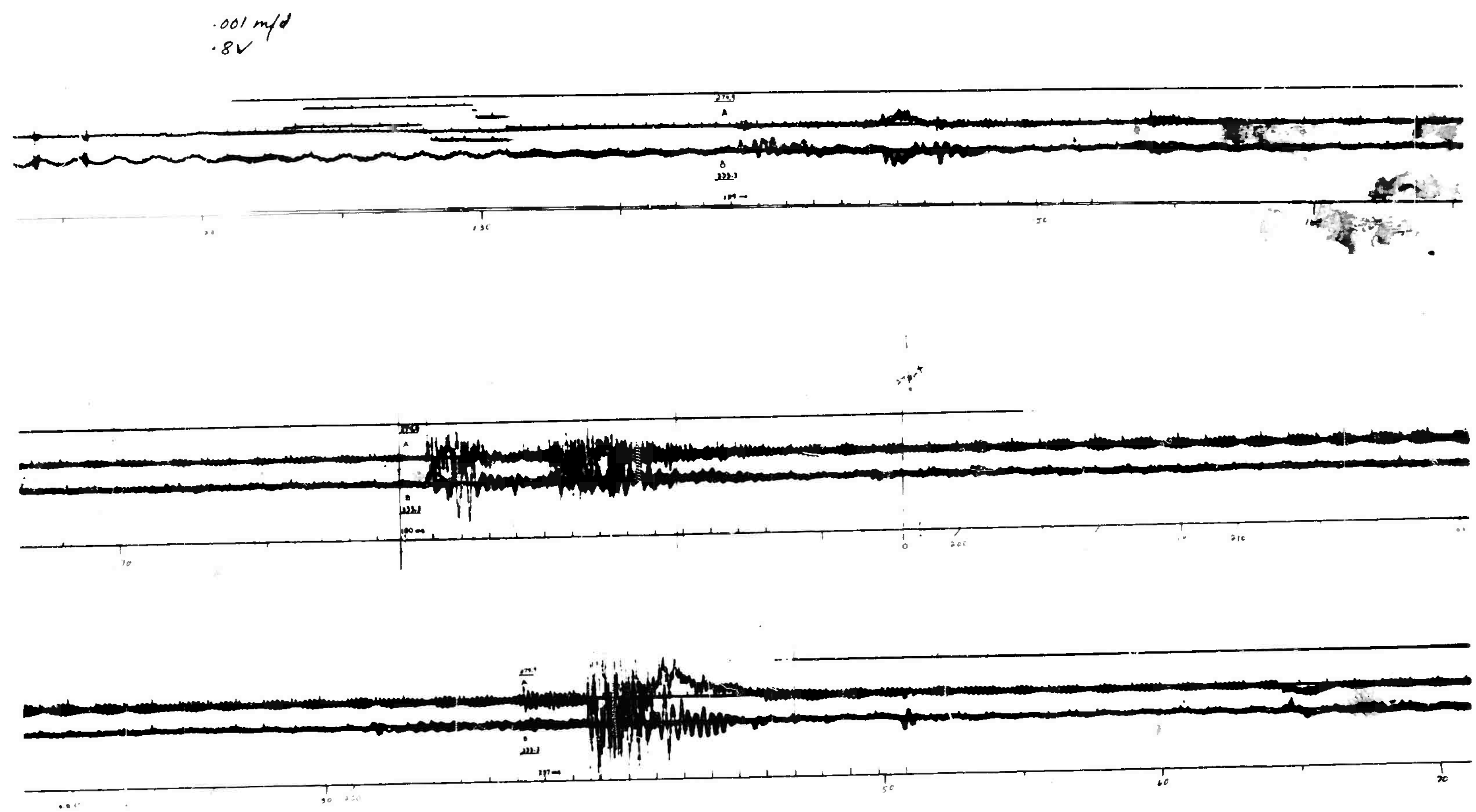

MD-82198-3-60

31 March 1960

Figure 12
Representative Test Record,
1st Phase

Blocked sections indicate: Upper, Base and Projectile Clamp Release; Center, Round Striking Positioners; Lower, Round Striking Buffer.

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APPENDIX B

TABLE 2

ACCELERATIONS OF 3"/70 ROUND DURING "CHAIN HOIST TO RAMMER CASE" PHASE OF RAMMING

Round No.	Peak Accelerations (Gravity Units): Chain Hoist Motion Starts A	Chain Hoist Motion Starts B	Case Clamp Releases A	Case Clamp Releases B	Projectile Clamp Releases A	Projectile Clamp Releases B	Round Strikes Positioners A	Round Strikes Positioners B	Round Strikes Buffer A	Round Strikes Buffer B
1	16	(1)	44	14	167	263	203	225	(2)	(2)
2	14	(3)	62	(3)	190	(3)	222	(3)	(2)	(3)
3	(1)	(1)	160	152	93	73	410	435	530	621
4	(1)	(1)	149	141	104	128	329	256	437	598
5	(1)	(1)	142	137	174	166	400	265	674	662
6	(1)	(1)	150	158	175	61	400	333	600	697
Average	15	-	118	120	151	138	327	303	560	645
Typical Transient Frequency	(4)		31KC		25KC		37KC		32KC	

A - Axial Component of Acceleration of Round
B - Vertical Component of Acceleration of Round
(1) - No appreciable deflection
(2) - Trace off edge of record
(3) - Only channel "A" operating
(4) - High frequency transients not present

TABLE 3

ACCELERATIONS OF 3"/70 ROUND DURING "RAMMER CASE TO BREECH" PHASE OF RAMMING

Round Number	Peak Accelerations (Gravity Units)					
	Rammer Motion Starts		Rammer Buff		Round Strikes Extractors	
	A	B	A	B	A	B
1	113	386	227	193	1920	1480
2	(1)	(2)	275	(2)	1989	(2)
Average	113	386	251	193	1955	1480
Typical Transient Frequency	(3)		37KC		34KC	

A - Axial Component of Acceleration of Round
B - Lateral Component of Acceleration of Round
(1) - Not readable
(2) - Channel "B" not operating
(3) - High frequency transients not present

APPENDIX C